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Main findings and recommendations from Workshop on Future Energy Systems, Technical University of Denmark, 19 - 20 November 2008

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Edited by Hans Larsen and Leif Sønderberg Petersen

Risø-R-1676(EN)
April 2009

DTU CLIMATE CHANGE TECHNOLOGIES

Risø DTU
National Laboratory for Sustainable Energy

Author: Hans Larsen and Leif Sønderberg Petersen (editors)

Title: What is the fast track to future energy systems with lower CO_2 emissions? Main findings and recommendations from the Workshop on Future Energy Systems at Technical University of Denmark, 19 - 20 November 2008

Division: System Analysis Division

As part of the DTU Climate Change Technologies Programme, DTU arranged a series of workshops and conferences on climate change technology focusing on assessment of and adaptation to climate changes as well as on mitigation of green house gasses (GHG). Each workshop targeted a specific technology problem area. The Workshop on Future Energy Systems took place at DTU 19 and 20 November 2008. The workshop developed and discussed recommendations for future climate change technologies. This report presents summary and recommendations from the workshop.

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Introduction

Hans Larsen and Leif Sønderberg Petersen

As part of the DTU Climate Change Technologies programme, DTU arranges a series of workshops and conferences on climate change technology focusing on assessment of and adaptation to climate changes as well as on mitigation of green house gasses (GHG). Each workshop target a specific problem area.

This workshop focuses on the challenges for the future energy system from a Danish perspective as well as world wide with regard to both technology needs and policy measures with particular focus on identifying a fast track to energy systems with lower CO_2 emissions

In the coming years, energy systems will be changed to consist of a combination of central units and smaller decentralized units – to a large extent based on renewable energy. At the same time there will be close links between the supply of energy and the individual end user of energy. These links will be based on extensive use of information and communication technology. This will allow end users to respond adequately to price signals and use the electricity for loading electric cars, laundry etc. while the electricity prices are low due to for example surplus of wind generated electricity.

The workshop assessed the perspectives for a rapid development of energy systems with more renewable energy in order to reduce CO_2 emissions. Furthermore, the workshop gives recommendations for the implementation of such energy systems. The recommendations are targeted at the research community, industry and public authorities. The recommendations include opportunities for synergy between the research community, the government and the energy industry as well as public authorities.

Risø Energy Report 7 was presented as introduction to the workshop by some of the authors.

The report outlines the current and likely future composition of energy systems in Denmark, and examines three groups of countries: i) Europe and the other OECD member nations; ii) large and rapidly growing developing economies, notably India and China; iii) typical least developed countries, such as many African nations. The report emphasises how future energy developments and systems might be composed in these three country groupings and to what extent the different technologies might contribute.

The workshop on Future Energy Systems took place at DTU 19 and 20 November 2008. This report presents summary and recommendations from the workshop.

Main findings and recommendations

Hans Larsen and Leif Sønderberg Petersen

Our energy system can be based on renewable energy

We can change the Danish energy system to depend mainly on renewable energy and cut CO_2 emissions by 50% before 2050 compared to 2008 emission level. The big challenge lies in the system itself, as this is the prerequisite for the interplay between various supply technologies and end use.

Denmark can in the long run become independent of fossil fuels by implementing efficiency improvements in all sectors including power stations, the building sector, industry and transport. At the same time, the share of renewable energy must be increased with more wind energy and increased use of biomass.

Such a radical transformation of the energy system takes time, among other things due to long life times of supply technologies. Accordingly, decisions and action are needed now.

The transformation requires:

- An interconnected intelligent power grid, integrated on a European level and able to accommodate a higher level of renewable energy.
- We can achieve much with known technologies in the short term, but there is a need for research into new energy technologies and systems to be introduced beyond 2050 when CO_2 emissions should be cut by 50% compared to the 2008 level.
- Definite framework conditions and directives from the authorities. The energy sector needs this before investing hugely in connection with a significant transformation of the energy system.
- More research in low-energy buildings. Countries like Germany and Austria are in the fore-front of this research area.
- Carbon capture and storage in power plants and energy-consuming industries until we are able to phase out fossil fuels, however, the costs have to be reduced .
- A European wide Transmission System Operator (ENTSO-E) – independent from power producers is needed. Reinforcements are needed on both National and European scale. An offshore grid is needed.
- Electricity storage is vital for the grid and for transport.

The EU has taken the global political lead with its ambitious targets for GHG reductions and an increased proportion of renewable energy.

The USA has focused much more on domestic energy security; its rapid increase in corn-based bioethanol is a clear example of a policy that addresses energy security but contributes very little to GHG reductions or longer-term supply stability.

At the global level, all known sustainable energy technologies must be used in order to control CO_2 emissions. However, the solutions are quite different in various regions of the world. In countries with rapidly growing developing economies like India and China it is obvious to expand with the best technologies, but it takes extensive cooperation with countries which are forerunners in development of sustainable energy systems. In the world's least developed countries there is a need for providing modern clean energy and electricity to everyone. Here the world's major economies should help transfer clean energy technologies, based on both fossil fuels and renewable energy. In these countries the key to obtain increased co-operation from developing countries for solving the climate change problem is to align climate change with development.

Action is needed now

In order to peak the CO_2 emissions within the next 15-20 years action is needed now. Discussions on the workshop indicates that among the most obvious actions are:

- Implementing energy savings and efficiency improvements in the building sector. And introduce demand response possibilities should be introduced for all consumers
- Introducing strong incentives for consumers to change behaviour in order to exploit renewable energy and energy savings to the maximum.
- Introducing the maximum possibly amount of power production based on technologies without greenhouse impact: Biomass, wind, solar, and nuclear in countries with experience in this technology. And develop conventional power plants to use best available technology and introduce IGCC integrated with CCS.
- Broad implementation of electricity storage. Pumped hydro storage is the best developed existing technology.
- With regard to the transport sector it is found important to move ahead with the introduction of electrical vehicles, provided that the electricity is produced from low or zero CO_2 energy sources.
- Introducing international, regional, national and local policies for promoting renewable energy and energy savings.
- For the least developed countries access to modern energy has higher priority than CO_2 emission reductions. Rural electrification must be firmly integrated in the general electrification planning and a change from traditional biofuels (wood leading to deforestation) to modern cooking fuels like kerosene and LPG must be initiated. Regional power pools is a potential efficiency measure at macro scale and would be essential in the case of large hydro in most cases.

Welcome and introduction to the workshop

Niels Axel Nielsen, Director*, Public Sector Consultancy, Technical University of Denmark*

The workshop organisers puts the question:

What is the fast track to future energy systems with lower CO_2 emissions.

We believe at DTU that the question has a complex answer and different answers may apply to different regions and economies.

We will in coming decades need to adapt the track and the strategy as the science and technology and the market development continue. However, it is extremely important that we do our best to discuss and identify the direction and the track as we see it to day. And then start moving along the track.

Therefore, I hope that the conference will give visionary input and good discussions and guidance. The thorough work by the IPCC panel point to the need to reduce green house gasses and other subsequent analyses, e.g. the Stern report show, that if we take swift and effective action now we can accommodate the costs.

The challenge is actually not only to reduce GHG emissions, but we need to reduce GHG emissions and at the same time secure energy supply to sustain a population growth from 6 to 9 billions and to eradicate poverty. And on a local and regional scale we also need energy supply security for geopolitical reasons and independence. We need food security, it requires energy and land use. And all this should be done in a world with limited resources of water and minerals.

This requires widespread technology development and deployment.

Therefore DTU has implemented a cross department initiative called *DTU Climate Change Technologies*. This term is chosen because technology will be a crucial element in solving the problem.

DTU Climate Change Technologies have four pillars. The objective of the first pillar is to accelerate the development and deployment of technology. We need urgent action and there should be equal weight on both development and deployment.

The next pillar focuses on initiatives to work efficiently with other world class universities. Thirdly we will enhance DTU's capacity to give advice to public authorities and private companies on climate mitigation and adaptation measures. Public authorities and private business will need factual, up to date, and holistic advice based on tools which take into account the complexity of the problem. Finally we will make sure that DTU's graduate program is in line with future requirements.

To kick start the first pillar we arrange workshops in 2008 and 2009. We invite participants from the private sector, from public authorities and from research. It is a key driver for development that there is strong interplay between the three parties. The scientist should develop innovative technology and the industry should make it commercially available and competitive. Only in this way we can ensure a strong market penetration. And public authorities should ensure that the framework conditions, taxes and subsidies are promoting the right kind of technology until it is competitive.

This workshop is the second in the series of ten workshops in 2008 and 2009, and it deals with one of the very important elements in the construction of a low carbon economy – namely the development and implementation of a new energy system. I am confident that the broad and distinguished participation from industry, science and authorities will give strong input to the discussions and make it a successful workshop.

Presentation of Risø Energy Report 7

Hans Larsen, Head of Division, Risø National Laboratory of Sustainable Energy

The report is the seventh of a series that began in 2002. The report presents state-of-the-art and development perspectives for energy supply technologies, new energy systems, end-use energy efficiency improvements and new policy measures. The report addresses the need for research and demonstration together with market incentives, and policy measures with focus on initiatives that can promote the development towards CO_2 reductions.

The report outlines the current and likely future composition of energy systems in Denmark, and examines three groups of countries:

- Europe and other OECD member countries
- Large and rapidly growing developing economies, notably India and China
- Least developing countries such as many African nations

The report is written by researchers from DTU together with Danish and International experts and based on the latest research results together with available international literature.

The world faces two major challenges within the energy sector:

1. Security of supply

2. Climate change

Climate change is widely recognised as the major environmental problem facing the world, and it is no longer relevant to discuss whether the climate is changing. The question is whether we go for +2 or +6 degrees raise in global temperature level.

The solutions are different for different regions

The countries of the OECD strongly influence the development of energy demand as well as new energy supply opportunities. The OECD countries are amongst the fastest in developing new renewable technologies such as wind power and PV. They are at the same time becoming increasingly dependent on imported fossil fuels. According to IEA's Energy Technology Perspectives the OECD share of world primary energy demand will decline from 49% in 2005 to 34% in 2050.

Rapidly-developing countries like China and India are important in shaping world trends in economic energy development and they have a strong influence on the possibilities for solving the climate problem. With their huge new investments in energy infrastructure over the coming decades, they have a rare window of opportunity to move towards a low-carbon development.

The rate of economic development in least developed regions like sub-Saharan Africa has been extremely low over the last decades. Per-capita energy consumption and CO_2 emissions are low, and climate change is in itself not a priority. The future development in these countries will depend strongly on economic growth. Large-scale infrastructure investments need to go hand in hand with the development of decentralised energy systems, and there is a strong need for cooperation with industrialized countries.

In Denmark, the CO_2 reduction strategies could concentrate on the following issues:

- Energy savings with annual reductions of 1–3% in energy consumption.
- More efficient conventional vehicles and plug-in hybrid vehicles.
- Increasing the share of wind power, in particular offshore.
- Increased use of biomass for building heating and process heat in industry and CHP plants.
- Development of second-generation biofuel technology for transport.
- Energy infrastructure development, including flexibility.
- New and improved market measures.

Some major issues in the global CO_2 reduction possibilities are:

- In the shorter term (up to 2030), the main contributors to GHG mitigation are demand-side measures, efficiency improvements in the energy sector, and reductions in emissions of GHGs other than CO_2.
- Many short-term energy efficiency measures even have negative abatement costs.
- In the longer term, there is a need for more new and renewable energy supply technologies such as wind, PV, bio. There is however a need to supplement these technologies with measures like nuclear and CCS

Recommendations

Denmark could profit by being in the front with developing a low carbon energy system that could increase independence as regards energy supply and give a competitive advantage in new energy technologies.

There is a need to reinforce Denmark's power transmission grid, in part to meet the needs of future offshore wind power plants.

Electricity storage is an important element in reinforcing the grid.

Another option is the establishment of an intelligent grid with two-way communication to facilitate the integration of more wind power.

Large-scale integration of renewable energy in Europe requires a pan-European transmission network to allow effective cross-border power trading and provide mutual support for security and quality of supply.

International collaboration and support for the introduction of new, more efficient, energy technologies for countries like China and India will be important.

It is important to expand the use of instruments like the Clean Development Mechanism (CDM) to further the development and implementation of low-carbon energy systems in developing countries.

Stimulating cooperation between existing regional power pools in developing countries will be essential in exploiting the large but regionally diverse resources such as hydro, coal and natural gas, which are needed to provide electricity to meet increasing urban demand.

Intensified research and demonstration for new energy technologies, particularly systems adapted to the specific needs of different regions of the world, and preferably in international collaboration, must be stimulated locally, regionally and globally.

Educating the next generation of energy specialists and engineers worldwide is important to the development and use of new energy technologies at local, regional and global levels.

Initiatives are needed to raise industrial energy efficiency at local, regional and global levels.

Globally, the building sector offers tremendous possibilities for saving energy, but incentives are needed to make this a reality.

Carbon capture and storage (CCS) could be an important medium-term option, allowing the world's large remaining reserves of fossil fuels to be used in an environmentally-benign manner. R&D and international cooperation in CCS should therefore be stimulated.

Risø Energy Report 7: Danish and global climate and energy challenges

John M. Christensen, Head of Centre, UNEP Risø Centre

Energy security – key concerns

- Changes in global distribution of demand and supply are driving national and regional concerns about secure supplies.
- Increasing import ratios of fossil resources in most OECD countries but also for example China and India.
- Importance of stable energy supply implies political focus on national control of supply and production, but in a global economy diversified supply is another option.
- Affordability of imports for low income countries.
- Micro level access to affordable and reliable supply.

Energy security – policy response options

- Concentration of fossil fuel resources: Government action aims to minimize the exposure to resource concentration risks in fossil fuel markets and includes moving away from fossil fuels, or diversifying supply routes and means.
- Energy system disruptions linked to extreme weather conditions or accidents: Government policies are generally precautionary in nature. Governments notably have an important role in preparing contingency arrangements for the management of, and recovery from, such incidents after they happen.
- Short-term balancing of demand and supply in electricity markets: Governments may for example establish independent transmission system operators (TSO) responsible for the short-term balancing of demand and supply.
- Regulatory failures: Government action aims to monitor the effectiveness of regulations and to adjust regulatory structures when inefficiencies are detected.
- Reducing dependency on fossil fuels evidently has most immediate synergies with CC policies.

Energy security in different development perspectives

"Higher oil prices are causing many net oil importing Sub-Saharan African countries to lose economic ground—costing them a cumulative loss of over 3 percent of gross domestic product (GDP)—and increasing poverty in those areas by as much as 4 to 6 percent." Jamal Saghir, Energy Director, World Bank (May 2006)

"In general cost of oil imports as part of the overall imports have declined compared with the "oil crises" in the eighties - for example Tanzania has gone from a share of 70% to now around 20%. Higher prices on locally produced non-oil commodities have also helped compensate the oil prices raises in a number of countries. " Davidson, FEMA, 2007

Climate change – IPCC conclusions

- Numerous changes in climate are already being observed at the scales of continents or ocean basins.
- Anthropogenic greenhouse gas emissions have most likely caused most of the observed increase in globally averaged temperatures since the mid-20th century.

- GHG emissions from the energy sector are the main anthropogenic source and the one where projected increases are highest and therefore need to be reduced.
- Stabilisation of GHG concentrations at “manageable” levels can be achieved by application of a combination of technologies that are on the market and those that are projected to be commercialised in coming decades, provided the political and economic incentives are in place for investments, cost reduction and further development and deployment of technologies.

Energy access and the poor

- Close to 50% of the world’s population is poor (< US$ 2.00 per day).
- Bulk of poor rely on traditional biomass (estimated global total = 2.4 billion).
- About 1.6 billion of the poor without electricity & clean/modern energy.

Core areas for international action

- Systematic support to clean energy development as a part of poverty reduction and economic development strategies.
- Commitment to long term financing of energy sector development, potentially linked with a Copenhagen agreement finance package.
- Increase global funding for energy poverty programs focusing on increased access based on clean and efficient technologies.
- Budget support where required - to address import security issues.

Danish strategy – key elements

Energy Policy Agreement of 21 February 2008. This agreement sets ambitious targets and contains a number of specific initiatives and means for the next four years. The overall targets of the agreement are:

- To reduce total energy consumption by two per cent in 2011 and by four per cent in 2020 compared with 2006 consumption.
- To increase the use of renewable energy to 20 % of gross energy consumption in 2011.

Key messages

There is no single or simple solutions:

- Action needs to combine different policies and approaches. Solutions that address both climate change and energy security at the same time are favorable.
- Long-term and predictable policy support is crucial to develop and sustain markets and industries.
- Market forces should be used where appropriate, but solutions are individual and no mantras exist.
- Lots of political, economic and institutional resistance to overcome along with personal perception by many types of actors, so awareness based on solid information is key with credible data on technologies, policies etc….
- Role of international agreements and institutions???

Risø Energy Report 7: China, India and other rapidly developing countries

Kirsten Halsnæs, Head of DTU Climate Centre

Rapidly developing countries like China and India together with other large and fast emerging economies are important forces in shaping the world trends of development, energy, and climate performance in coming decades. These countries, due to their enormous new investments in energy infrastructure in the coming years, have the rare opportunity of transition toward low carbon development and low-cost GHG emission reduction.

China's and India's remarkable and robust economic growth over the last two or three decades has led many people to believe that both countries will continue to grow rapidly in the decades to come and such economic growth will pose enormous challenges in satisfying energy demand and mitigating greenhouse gas emissions.

With their vast territories and great differences in regional circumstances, China, India, and other rapidly developing countries will need to use almost every technological solution available to meet energy and climate challenges. A few technologies, however, are especially important. For electricity generation, the most important technologies for China and India will be those relating to clean coal, followed by nuclear power, hydro, wind, and solar. For the transport sector, public transport and clean vehicle technologies will be critical. Various energy efficiency technologies are also important to slow down energy demand increase and provide low-cost GHG emission reductions.

China and India are already taking measures to address the economic, social, and environment challenges caused by their rapid increase in energy consumption and GHG emissions. This includes ambitious targets for renewable energy and energy efficiency, increased domestic production, and international technology and cooperation.

Siemens: Does the industry have enough air to breathe?

Prof. Dr. Dieter Wegener, CTO, Siemens Industry Solutions

CO_2 abatement of Siemens products and solutions already more than 20 times greater than Siemens own GHG footprint.

The three core criteria of Siemens Environmental Portfolio:

General criteria to qualify products/solutions

Renewables: All renewables qualify

Examples:

- Wind power
- Grid access for wind power
- Steam turbines for solar thermal power

Environmental technology: All environmental technologies qualifies

Examples:

- Water technologies
- Air pollution control

Energy efficiency: Products and solutions with exceptional energy efficiency qualify

Examples:

- Combined-cycle power plants
- High Voltage Direct Current power transmission
- Efficient lighting

Siemens expect their Environmental Portfolio to grow by at least 10% percent per year

Danish Energy Industries Federation: A bright green strategy

by Jørgen Mads Clausen, Chairman of Danfoss and Danish Energy Industries Federation

Tackling climate change is a pro-growth strategy.

Economic growth and welfare can be maintained without influencing the climate negatively.

This is what we have experienced in Denmark, and this is what we call "The Bright Green Strategy".

Here technology has a central role to play.

Bright Green is a modern trend in international environmentalism, combining economic growth and sustainable technology.

With the development of sustainable energy solutions, Danish Industry is an international role model for Bright Green, and will continue its efforts to spread the mindset before, during and after the United Nations' 15th Climate Change Conference in Copenhagen 2009.

Why focus on technology?

Demography and wealth is difficult to influence. But energy intensity and CO2-intensity may be influenced by choice of technology. (Kaya Identity)

Kaya Identity and policy response

- Increase energy efficiency
- Change the energy mix
- Increase abatement efforts
- Change of lifestyles
- Change the structure of the economy
- Decrease/contain increase in per capita incomes
- Reduce population growth

What to do?

- Mobilise all major economies to reduce emissions as soon as possible
- Strengthen global market mechanisms to reduce emissions, linking developed and developing regions
- Ensure all cost-efficient climate technologies are deployed and developed

What to do about tech-transfer?

- Carbon markets must continue to be developed with the goal of establishing a global carbon market.
- Confidence in the continuation of the Clean Development Mechanism (CDM) and Joint Implementation (JI) for the post-2012 period must be strengthened. Emission Trading Schemes, not least the EU ETS, must allow for the purchase of an adequate number of CDM and JI credits.

- CDM and JI must be expanded, supporting essential reduction opportunities, such as the transfer of renewable and energy-efficient technologies, protection of forests, implementation of carbon capture and storage or nuclear projects. Capacity must also be built in least developed countries.
- Other means of technology transfer need to be applied: WTO agreements and solutions to the violation of Intellectual Property Rights.

DONG Energy: Future energy systems

Anders Eldrup, CEO, DONG Energy

Power production capacity is decreasing.

UK and DE expect substantial shortage in 2020, and plants are rather old.

There is no easy way to an increased share of renewables

In the short run the choice is between fossil fuels and nuclear.

- Environmental concerns render more large hydro unlikely
- Public acceptance of on-shore wind is faltering. Great potential off-shore but very costly
- Large deployment of solar in Germany. Very high subsidies
- Biomass can replace coal but only to some extent
- Wave is an immature technology

Carbon-free coal can secure supply and reduce emissions

- Nuclear is unwanted in many countries - Fossil fuels such as gas, oil and coal are the alternative.
- Fossil fuels have issues of security of supply - Oil and gas in high demand controlled by politically unstable countries. Coal is abundant
- Coal contributes significantly to climate change - Emissions from coal must be reduced, e.g. through CCS. Presupposes subsidies or higher carbon emissions prices

Gradually renewables will supply more of overall consumption

- DONG was awarded with 'Cleaner Energy Initiative of the Year 2007' for the Castor-project at Esbjerg-power plant
- Biomass such as straw and wood chips used extensively in power plants
- Increased deployment of wind energy, for instance Horns Rev II, the worlds largest off-shore windmill-park
- Bioethanol from Inbicon
- Electrical car to be launched by Project Better Place Denmark

More renewables create challenges to the future energy system

Today:

More renewables means more unstable energy. Today the fossil fuels fired power plants provide the baseload. Renewables are a supplement.

In the future:

Renewabels meet the mayority of demand while fossil fuels fired power plants fill out the gaps. Back up power plants are costly.

Need for increased transnational grid integration

Grid-challenges:

- Increased import to ease the back-up problem

- Increased export to alleviate overproduction
- Export need when highest is at 6000 MWh
    - Today northbound DK export capacity is at 4.200 MWh
    - Southbound, in the north of Germany, wind-conditions are similar to Denmark

Future technologies and systems - from a Nordic research funding perspective

Birte Holst Jørgensen, Director, Nordic Energy Research

A sustainable future should combine environmental protection and climate change with economic growth and energy security of supply.

The Nordic Prime Ministers met at Riksgränsen, 8 – 9 April 2008 in order to seek joint responses to joint challenges. Among their priorities were:

- Cutting edge research and innovation in energy, climate and environment.
- Sustainable Nordic model combining reduced emissions with economic growth.
- Support for environmentally friendly energy solutions and other climate measures in developing countries.

On 28 October 2008 the Nordic Council of Ministers approved a joint research and innovation programme:

- 1-year cross- sectoral process at national and Nordic level
- SEK 480 million (~50M€) in the period 2009-2013
- Joint programming for 6 thematic areas:
    - CCS
    - efficiency/nanotechnology
    - integration of large scale RES in the energy system
    - sustainable bioenergy
    - climate change and the interaction with the cryosphere
    - climate impact and adaptation
    - Industry to be engaged in subprogrammes

Nordic prospects for energy research infrastructures

- Research infrastructures for clean energy RD&D urgently needed.
- Distributed and networked RI needed covering various technology options and diverse geographical and climatic conditions.
- Outcome from Nordic conference 12 – 13 November 2008 on research infrastructure include the following:
    - Carbon capture and storage research and demonstration facilities .
    - Wind resource and turbulence measurement networks, based on LIDAR and covering different types of terrain .
    - Cryospheric and climatological measurement infrastructure in Arctic and northern conditions.
    - Carbon sink (e.g. forestry) measurement and assessment.

Current trends and visions for the future for OECD countries

Univ.-Prof. Dr.-Ing. Ulrich Wagner, Energy Economy and Application Technology, TU München

Ifeon is a German optimisation model for upgrading the power plant mix. The model should lead to a cost-effective power supply in Germany, and it includes:

- Power plant mix:
  - Technical specifications
  - economic parameters
- Technical, economical and political framework
- Development of prices:
  - Fuels
  - Carbon dioxide emissions
  - Investment costs
- Power plant shut downs
- Power supply reliability
- Development of power demand
- Development of power generation:
  - hydroelectric
  - biomass
  - wind
  - solar
  - CHP

3 rules, applicable under any technical, economical and political frame conditions can be deduced:

- Decentralize efficiency
- Centralize emissions
- Diversify primary energy mix

Energy trends and future visions in emerging economies: An analysis for India

P.R. Shukla, Indian Institute of Management, Ahmedabad, India

Transition to sustainability

- In coming decades, China and India will be major contributors to incremental global energy demand and CO_2 emissions.
- China and India's per capita energy consumption and CO_2 emissions would remain lower than OECD for many decades.
- China and India can make development choices that avoid lock-ins and deliver energy and environmental co-benefits.
- Regional cooperation in Asia can be an deliver significant energy, environment and sustainability dividends.
- Technology cooperation and financial transfers from developed countries are important for sustainable energy and environment pathways in emerging nations.

Align development and climate actions

- Mainstream climate actions.
- Mainstreaming climate action in development strategies yield multiple co-benefits.
- Promote actions suiting sustainable and climate-friendly development path.
- 'Reduce, Reuse and Recycle (3R)'.
- Infrastructure technologies that act as backbone for low carbon activities (e.g. railway and information networks).
- Low carbon substitutes (e.g. IT for transport).
- Use combination of direct and indirect policies.
- Regional Cooperation to diversify energy mix.
- Energy intensity targets.
- Carbon price.

How do we make Denmark peak before 2020 when it comes to CO_2?

Jeppe Bjerg, Senior Analyst, Office of Sustainable Policy and Technology, International Energy Agency

This presentation is based on our global analysis Energy Technology Perspectives 2008 and discuss insights for the challenge to reduce CO_2 emission in Denmark by 20% in 2020.

World Energy Outlook 2008

The Reference Scenario (RS) takes account of those government policies and measures that were enacted or adopted up to mid-2008, but not new ones, providing a baseline against which we can quantify the extent to which we need to change course. So this is telling us about what will happen unless new policies and measures are adopted.

World primary energy demand projected in RS grows by 45% from 2006 to 2030. It is worth noting that demand grows at a slower rate than projected in WEO-2007, mainly due to higher energy prices and slightly slower economic growth - as well as new government policies to curb demand and emissions growth introduced in the past year.

Coal grows fastest among fossil fuels – and even from a low starting point - modern renewable technologies grow most rapidly, by 7.2% p.a. (excl biomass), overtaking gas to become the second-largest source of electricity, behind coal, soon after 2010.

These trends are patently unsustainable – economically, socially and environmentally. Rising oil and gas demand would lead to higher imports and reliance on OPEC, heightening concerns about energy security, while increased use of fossil fuels would worsen climate change.

There is a need for change if the world wants to get on a sustainable path.

Let me focus on the 450 Policy Scenario – because this is really what we want to focus on.

Emissions will continue to increase in the near future and concentrations will initially overshoot the 450 ppm level, before declining – this is necessary, as otherwise emissions would have to peak in 2-3 years. It will take time to agree and implement a global climate change framework – and a substantial proportion of energy emissions are already locked-in. Three quarters of 2020 emissions in the power sector come from plants that already exist today, or are in the process of being built.

450 ppm

As well as even more widespread deployment of existing low-carbon technologies, 450 Policy Scenario can only be achieved through stepped-up research, development and subsequent demonstration and deployment of new technologies, to achieve sharp reductions in emissions after 2020. It assumes extensive deployment of CCS in OECD+ and Major Economies, including retro-fitting. In the transport sector, it requires the introduction of advanced biofuels and the penetration of electric or fuel-cell vehicles.

Energy Technology Perspectives 2008

This is a study about the role of technology and technology policy. It is not a study about climate policy instruments. It was launched June 6th, Tokyo, guided by the Committee on Energy Research and Technology and in close cooperation with the Working Parties, Expert Groups and Implementing Agreements. It builds on ETP2006 and WEO2007, but expands the analysis considerably.

The report contains roadmaps for 17 groups of technologies that cover over four fifths of the total emissions reduction. Each roadmap contain:

- Potentials
- Pathways to commercialization
- Technology targets
- How to get there
- Key actions needed
- Key areas for international cooperation

Only the BLUE Map scenario is consistent with a long-term stabilisation at 450 ppm CO_2.

The BLUE Map scenario explores the energy implications of a reduction of global Greenhouse Gas (GHG) emissions to 50% of current levels by 2050. In this scenario, CO_2 emissions would peak in the next decade, fall to 14 Gt in 2050, and stabilise afterwards. This most ambitious scenario could result in a stabilisation of CO_2 concentrations at 450 ppm. It should be noted that other emission scenario pathways could meet this target as well, and that the timing of the peak could also be somewhat later. This issue is not further elaborated in this study.

In both ACT and BLUE energy efficiency improvements in buildings, appliances, transport and industry and power generation represents the largest and least costly savings.

Next in the hierarchy of importance come measures to substantially decarbonise power generation – massive deployment of renewables, CCS on fossil fuels plants and nuclear. Up to USD 50/ton CO_2

Renewables will become extremely important in the BLUE scenario

As said before the share of all electricity generation from renewables increases from 18% in 2005 to 46% in the BLUE Map scenario. In the BLUE Map scenario, variable renewable generation (wind, photovoltaics and marine) produces around 20.6% of electricity worldwide in 2050 (about 3 500 GW).

Transport is really the challenging sector

Costs are high and uncertain, new technology is at development stage for FCV and EV. And it is expensive – the transport sector accounts for almost 85% of total investments in the Baseline scenario. But if an emission trajectory in compliance with a 450 ppm scenario is to be realized new solutions are to be found for this sector.

The car fleet of the future is radically different from today. This graph shows the market shares in 2050 of various technologies. Four BLUE variants have been developed. This accounts for the fact that we are not certain about the direction of the technology transition. BLUE Map includes mix of efficient ICEs, vehicles that use electricity from the grid (plug-ins and battery electric vehicles) and hydrogen fuel cell vehicles.

In the least optimistic scenario BLUE Cons neither of these options reaches cost-effectiveness and hybrids and plug-in hybrids are applied to their maximum extent.

The emissions in BLUE Map in 2050 are about 20% below the level of 2005. However the CO_2 reduction in transport is not the same in these scenarios. In BLUE Cons emissions in 2050 are 2.5 Gt above the other three BLUE variants and 1.5 Gt above today's level. This shows the enormous challenge in this sector and the need for new technology.

And bear in mind that cars account only for half of all fuel use. In important finding of this study is that other transport modes pose an even greater challenge, as hydrogen and electrification are not viable options.

Buildings

Buildings is a two speed sector. We can change appliances and energy equipment in relatively short time frames, but building shells last 50-100 years in OECD

Urgent action is therefore required: buildings built today may still be standing in period 2050-2100!

In BLUE, all new buildings must meet passive house thermal standards in cold-climate countries from 2015. Refurbishment to this standard will need to be achieved (200 million homes in OECD by 2050)

Fuel switching is vital when we move from a stabilization scenario to BLUE. Massive switch to heat pumps, solar hot water heating, solar PV and electrification in general where possible

Distributed generation, smart metering important

Transport

Although engine-related and non-engine-related vehicle technologies have significant potential to improve fuel economy and reduce emissions, they require continuous improvement rather than RD&D breakthroughs. For RD&D breakthroughs, the most promising areas are concentrated on specific vehicle and fuel technologies.

For the BLUE Map scenario and its variants, the transport sector will require new solutions. In this scenario, efficiency gains by gasoline and diesel vehicles provide about half the CO2 reduction. The other half comes from the use of biofuels and introduction of electric vehicles (EVs) and fuel cell vehicles (FCVs).

The chapter identified technology RD&D needs for various sectors.

Key messages

- We are facing an urgent challenge in the energy sector and we need a global solution
- Emissions stabilization – mainly energy efficiency and power sector measures (ACT scenarios)
- Halving emissions by 2050 implies deep cuts for transport and industry (BLUE scenarios)
- Marginal cost BLUE USD 200/t (optimistic technology estimates)

- The cost uncertainty increases with ambition level
- USD 45 trillion additional investment needs for BLUE (1% of GDP)
- Important supply security benefits

Report from working group 1 – Future technologies and systems

Chairman: Lars Hansen, Danish Energy Industries Federation
Referee: Brian Elmegaard, DTU Mechanical Engineering

Several technologies and system improvements were suggested in common understanding.

The suggestions were divided in short term (2020), and mid to long term (2050) solutions for research, development and implementation.

Short term solutions

These technologies should be implemented as soon as possible, depending on their level of development. Some do need research before implementation. The most important message was: *We need all available technologies to obtain the CO2 peak within the next 10 – 20 years!*

- Energy savings and efficiency is straightforward solutions that will result in significant improvements. As an example, improvement in the integration between heating and power production was discussed. Improved building insulation and better integration e.g., district heating or heat pumps.

- Power production should be based on technologies without greenhouse impact: Biomass, wind, solar, nuclear.

- Conventional power plants should be developed to use best available technology. When carbon capture solutions are ready commercially, they will be a significant improvement of the greenhouse emission situation as a temporary measure. IGCC integrated with CCS may be one of the best solutions.

- Electricity storage should be implemented to largest possible extent. Pumped hydro storage is the best existing technology and should be implemented wherever possible.

- Better system control measures should be implemented, even though the need was questioned based on the current Danish situation.

- Demand response possibilities should be introduced for all consumers – This may be done by changes in the taxation system to make it "smarter", i.e., make the right incentives. Generally, a more transparent market is needed.

Mid to long term solutions

Several technologies not ready for short term use were mentioned:

- Storage of electricity in batteries and future type Compressed Air Energy Storage (CAES)
- Wave
- 2nd generation biofuels
- Solar cells 3rd generation
- Fusion
- CCS is necessary in the short term, but is maybe not the right solution in the long term.

R&D demands

Some of the research and development needs to reach the future system are:

- We need to develop on integrated distribution networks
  - Smart grids
  - Transnational interconnectors
  - International market control
- We need to deal with the challenges of the transport sector
  - Increase public transport – electrification, infrastructure
  - I.e. electric cars are preferred to hydrogen (maybe methanol)
  - Avoid long-haul trucks
  - Also look into ships, planes with an open mind towards technology mix, e.g. biofuels
- We need huge public funding of technological development
  - Support and guarantee of consumer investments
  - Increase funding of R&D all levels
  - Learn from other areas
- We need to be cost efficient in our final technological choices
- Barriers
  - Material technology (development of new energy materials for different energy technologies)
  - Funding of demonstration projects

Report from working Group 2 - Current trends and visions for the future for OECD countries

Chairman: Nicolai Zarganis, Danish Energy Authority
Referee: Stine Grenaa Jensen, Danish Energy Association

Important sectors:

- Transport: fuel efficiency along with alternative fuels (electricity, gas)
- Buildings: heating, cooling, insulation (energy efficiency)
- Power: CCS also for biomass, sea activities (biomass and wave)

The building sector is one of the areas that are very important especially heating including heat pumps. The most interesting question in this area is the lack of focus on renewable energy and energy savings not only for private households but also for industry. Too little of the potential for renewable energy and energy savings is actually used, and often because exploitation of renewable energy and energy savings is not part of planning processes, e.g., when building factories. Furthermore, there is a lack of knowledge sharing which limits the “good example” to be implemented. Some solutions discussed in the working group was: local authorities demand to se an “energy plan” before approving, labelling, minimum standards on international level, and best practices made public.

In the transport sector it is important also to focus on fuel efficiency and not only other energy carriers and other fuels. In this sector it is important to look at taxation on cars, there has to been tax advantages when buying, e.g., electrical vehicles. The road toward a more sustainable transport sector was agreed to be through using gas in the transport sector. That is, we start with gas/biogas in the cars and the in time switch to electrical cars. When this is done we should use the biomass directly in the power sector in order to avoid to big losses in the conversion process. A last point for implementing electric vehicles is the need for standardization of, e.g., batteries.

In the power sector it is important to include discussions on CCS, as CCS is also a technology which can be developed for use on biomass plants. Following, we see Denmark as a potential frontrunner on developing CCS for biomass, and hence, generate growth in Denmark. The group would like to see a European requirement for CCS on all new coal fired power. Another area of technologies discussed for power production was different see technologies like wave and offshore biomass production (e.g. sea salad).

- Security of supply
  - Important aspect which put transport in first priority
  - Other measures than CO_2 is important
  - Need for storage and/or transmission
- Transport (cars, busses, train)
  - Good for energy system interaction (security of supply)
  - Need for standardization, restructuring
  - Highlight other benefits for consumers (noise, O&M cost, price on power)

The group finds it important to recognize that considerations of the future energy system has to include not only climate issues, but also local environment, security of supply and economic efficiency. Including the consideration of security of supply, local environment, and climate issues, it is important to put the transport sector in first priority. It was discussed to shift to alternative fuels with gas as a start, followed by electricity. The group found it more useful to put biomass into the power sector and then into car, caused by the high energy loss in biofuels. One of the arguments is also that we need larger interaction between different parts of the energy system in order to handle large amounts of renewable energy.

Changes in attitudes

CO_2 is not considered a pollutant, since it have no direct local effect, that means that value of CO_2 is not included in economic evaluation, and action is only taken if payback time is less than 2 years. This leads to lacking incitements to invest in “clean tech”
The discussion of why profitable energy savings are not implemented lead to a discussion of how consumers, banks, venture capitalists, company boards etc. are excluding the evaluation of CO_2. The main problem for this is that we are not considering CO_2 as a pollutant that we have to take into consideration. It is only optional. To change this all of the above has to change attitude. E.g. banks have to lend out money for energy savings with payback timer over 2 years, and politicians have to be part of creating an stable investment climate for “clean tech”.

Consumers should change behaviour with regard to investment and consumption and change investment behaviour with regard to the pay back time of higher investments in low emission technology in refrigerators, cars etc. Consumers also have to view energy as a commodity that can be spent when price is right, e.g. be flexible in our power consumption.

The working group finds that we need to find the right balance between market and regulation. There are two many market imperfections to leave it all to the market, but market incentives are important to drive product development, why we need both aspects.

- International policies
  - Increased knowledge sharing (best practices)
  - Minimum standards
  - Guidance and labelling on industry products as well as others
  - International agreements on money for R&D from OECD (technologies, systems)
- Regional policies
  - Planning (grid planning), focus on investments
  - Market design
  - Remove barriers (e.g. administrative)
- National policies
  - Regulation from local authorities with respect to energy plan for new investments
  - Differentiated subsidies/taxation on appliances and/or cars
  - Government to take the lead (lead public spending to energy)

In order to find the right way to the energy future, we have to find the right balance between international, regional, and national policies. And since, we need both markets and regulation this balance is hard to find. The bullet list above gives a suggestion of where the group finds different aspects of the policies needed for developing the future energy system.

Report from working group 3 and 4 - Current trends and visions for the future for both big developing countries and LDC's

Chairman: Geert Aagaard Andersen, Ministry of Foreign Affairs of Denmark
Referees: Subash Dhar and Gordon A. Mackenzie, The UNEP Risoe Centre on Energy, Climate and Sustainable Development, the Technical University of Denmark

Aligning climate with development

The combined working group discussed issues both for large developing countries like China and India, and LDCs such as in Sub-Saharan Africa, A general undercurrent of the discussion was that development is the primary issue for these countries, followed by climate change. Aligning climate change with development is therefore key to getting greater co-operation from developing countries for solving the climate change problem. A focus on clean and efficient energy which also delivers general development benefits could be one of the approaches.

The discussions identified the key development challenges and also the origin for climate challenges if current development pathways are continued with.

Development challenges

The discussants broadly focused on two development challenges related to energy: (i) providing electricity to rural areas where the majority of population resides in both the large developing countries like India and China and the LDCs and (ii) access to cooking fuels. Though both are essentially developmental problems there was a debate on the extent to which aligning them with climate change can help in delivering some co-benefits.

Rural electricity

The issue of rural electrification addressing the people with no electricity at present was discussed extensively. One of the conclusions was that rural electrification needs to be more firmly integrated in the general electrification planning in order to succeed since there is evidence that parallel structures have failed in many cases. The choice of relevant technologies was discussed and CC finance could play a facilitating role both to further the process in general and to increase the use of clean energy forms.

Cooking fuels

Almost 2.5 billion people use traditional biomass for cooking. This large dependence on biomass for cooking coupled with inefficient devices contributes to a higher demand for biofuels. In addition to this in cramped urban settings cooking contributes to indoor air pollution which has severe health consequences. In India though rural population is still mainly using biomass in urban settings due to supply side interventions (fuel subsidies and improved availability of commercial fuels) a large number of people have moved up the energy ladder. Demand side measures (improved cook stoves for bio fuels) have found it difficult to make a meaningful contribution to the cooking scene in India. In Africa improved cook stoves have had mixed success, with large penetrations rates in some countries (e.g. Kenya) and more disappointing results elsewhere. In the case of Africa supply side interventions have similarly had little impact, with people in urban areas predominantly using charcoal in most countries, and the rural population using firewood. Wood fuel is not now considered to be a primary cause of deforestation, although charcoal production for the urban centres, harvesting wood unsustainably, does result in local deforestation.

The movement in cooking fuels on the energy ladder from traditional biomass to fossil fuels like kerosene and LPG will have minor climate change impacts however, and it would happen only with the help of subsidies which many local governments can not afford. The biomass resources could be used much more effectively and provide a basis for local energization, but this will require integrated national and local policies linked with the agriculture and forestry sectors. Depending on the source of biomass it may or may not be a major climate issue.

Climate challenge - Power sector

Large scale power generation is a major emission source in the big countries, but also in LDCs there is a similar trend, albeit at much lower levels of total emission. The power sector is highly coal intensive in China and India. The more alarming trend is that even the future energy system in these two countries would remain wedded to coal on account of relatively stable and cheaper prices and domestic availability. China is adding coal-fired capacity at a fast pace, using supercritical technology which has a higher efficiency than conventional subcritical coal plants. China is also exploring other energy efficient coal technologies like ultra-supercritical and integrated gasification combined cycle technologies. China is likely to emerge as the main technology provider for cheap and efficient coal power plant technologies. Cheaper and more efficient coal based plants reduce the attractiveness of cleaner options like hydro, gas and renewable. In a broader context, decreasing costs of coal costs will not be restricted to China alone and there is every possibility that coal based technologies will change the technology markets in India and LDCs.

The group discussion focused on the challenge posed by coal, and realistic alternatives to such a path from a technology perspective were examined.

Carbon capture and storage

A lot of optimism has been generally expressed about Carbon capture and and storage (CCS) as a contribution to solving the global climate problem. However there were concerns with respect to the high emitting countries like China and India about the realism in linking point sources (power plants) with carbon storages in terms of costs of infrastructure. In China and India there are limited depleted oil and gas wells which are the cheapest ways of sequestering carbon.

In addition to the paucity of cheaper storages for CCS, there was a concern about the adverse impact of CCS on sustainable development. CCS would make these countries dependent on a single fuel – coal. This dependence would in a longer term impact energy security, as the fuel mix would not be well diversified and there would be dependence on imports for many countries.

Hydropower

Large-scale hydropower was examined seriously as an alternative to fossil-fuelled power generation. However the hydro issue was found to involve sorting issues related to water sharing, addressing the problem arising from public goods or bads like irrigation and floods, besides financial constraints which means that moving in this direction will require government involvement, regional cooperation and possibly elements of investment guarantees. In addition there was the issue of political instability within some countries where this development is expected to take place. The issue of how Climate Change will impact the future hydro resource availability was another factor adding to the complications. In the end projects involving building of large dams would also require addressing problems arising from rehabilitation, and bio diversity.

Regional power pools

Regional power pools were seen as a potential efficiency measure at macro scale and would be essential in the case of large hydro in most cases.

Measures for promoting climate action

Financing

If Renewable Energy and Energy Efficiency are to be realistic alternatives it will require massive international financial support, but there was concern about the ability to get to this scale fast enough.

Domestic policies & regulation

Energy efficiency is clearly an important issue not just at the generation side but in the end uses, major industrial sectors offer potential with few big actors but implementation in small scale industries and households/service will require dedicated policy and regulation with strong enforcement capabilities which is generally not there now

Clean development mechanism

For the political discussions it is clearly necessary to look at the best models for technology and funds transfer and in the development interface, the current CDM structures are not the most effective. There needs therefore to be a distinction between the market focus on GHG reductions and the more development driven investments.

Regional groupings

Regional organizations already active in Asia and Africa can be used for helping in coordinating projects where the benefits and costs are shared by more than one country. This coordinating would be quite important for building large hydro power projects, regional power pools and regional gas grids.

Report from working group 5 – How do we make Denmark peak before 2020 when it comes to CO_2?

Chairman: Lars Hansen , Danish Energy Association
Referee: Peter Meibom, Risø National Laboratory for Sustainable Energy, the Technical University of Denmark

The task of working group 5 (WG5) was to discuss the possibilities of significant reductions in Danish CO_2 emissions within 10-15 years from now. WG5 spend some time discussing how to organise the discussions in the group. Due to the large number of participants two sub-groups were formed, one discussing measures related to energy supply and production, and one discussing measures related to energy demand. After discussions in the sub-groups, the whole group met and made common recommendations.

The sub-group related to energy demand discussed:

- Possibilities for changing behaviour of energy consumers as investigations have shown very large differences in energy consumption of similar households due to behaviour:
    - New research: find top 5 priorities of consumers and include an incentive of energy saving.
    - Information, technical measures making it easier to save energy for the consumer e.g. automatic light control.
- Electric cars:
    - Some participants were uncertain about the availability of battery technology capable of delivering the performance expected (even on a freezing winter morning) and with a reasonable price.
    - Need for Danish research with battery technology to be started up? Can experiences within fuel cells be used when designing batteries?
    - Lets get some electric driven vehicles on the road to get real-world experience with the performance: demonstration projects (200-500 cars on the road).
- Changing transport modes in larger cities: bus lanes, bike cycle lanes, no new parking spaces.
- Move transport energy consumption into ETS sectors by electrification i.e. usage of electric driven vehicles.
- Heat pumps: change taxation/possibilities for usage of electricity to produce heat.
- More research within low-energy buildings: Denmark is not in the fore-front of this research area anymore compared to e.g. Germany and Austria.

The sub-group related to energy supply and production discussed:

- Transmission grid:
    - More power and money to European wide Transmission System Operator (ENTSO-E) – independent from power producers.
    - Reinforcements needed on both National and European scale.

- How to overcome local resistance – by going underground?
- Offshore grid.

- Production technologies:
  - R&D and demonstration in CO_2 neutral technologies.
  - Production support for efficient CO_2-neutral technologies.
  - Requirement for usage of fossil fuels is usage of CCS.
  - Power system able to integrate a range of different (decentralised), technologies.
  - Optimise usage of biomass and waste in electricity and heat production.
- Integration of heat, power and transport:
  - Find the synergies: Power plants producing synthetic fuels and bio ethanol, Heat pumps.

Panel discussion

In the panel

Lars Hansen, Danish Energy Industries Federation

Nicolai Zarganis, Head of Division, Danish Energy Authority

Geert Aagaard Andersen, Head of Department, Ministry of Foreign Affairs of Denmark

Lars Aagaard, Deputy Director, Danish Energy Association

Jens Rostrup Nielsen, Director, Special Projects, Haldor Topsoe A/S

Katherine Richardson, Chairman, the Danish Climate Commission

Chairman

Hans Larsen, Head of Division, Risø National Laboratory for Sustainable Energy

The reports from the working groups were presented by the referees. Working group 3 and 4 was merged. The reports are presented above.

Important issues discussed in the following panel debate were:

- Efficiency improvements are the low hanging fruits to pick in the efforts for reducing the energy consumption.
- There is a great potential for energy savings and exploitation of sustainable energy in the building sector.
- More renewables make up a great challenge for the energy system.
- More renewables increases the need for electricity storage dramatically.
- How far can renewables take us? Is 100 % realistic?

A summary of the conclusions from the working groups and the panel discussion are presented in the chapter "Main findings and recommendations" in this report.

Programme

19 November 2008 – Auditorium 54

08:30 – 09:00	Registration and coffee
09:00 – 09:15	Welcome and introduction to the workshop Niels Axel Nielsen, Director, Public Sector Consultancy, Technical University of Denmark Chairman: Henrik Bindslev, Director, Risø National Laboratory for Sustainable Energy
09:15 – 10:15	Presentation of Risø Energy Report 7 Hans Larsen, Head of Division, Risø National Laboratory for Sustainable Energy
10:15 – 10:30	Refreshments
10:30 – 11:30	Presentation of selected chapters from Risø Energy Report 7 Kim Dam-Johansen, Head of Department, DTU Chemical Engineering John M. Christensen, Head of Centre, UNEP Risø Centre Kirsten Halsnæs, Head of DTU Climate Centre
11:30 – 13:00	Key note speeches Dieter Wegener, Chief Technology Officer, Industrial Solutions and Services, Siemens Jørgen M. Clausen, Chairman, Danish Energy Industries Federation Anders Eldrup, Chief Executive Officer, DONG Energy A/S
13:00 – 14:00	Lunch
14:00 – 16:00	Keynote presentations Chairman: Hans Larsen, Head of Division, Risø National Laboratory for Sustainable Energy Future technologies and systems, Birte Holst Jørgensen, Managing Director, Nordic Energy Research Current trends and visions for the future for OECD countries, Ulrich Wagner, Professor, Technische Universität München Current trends and visions for the future for big developing countries like India and China Priyadarshi R. Shukla, Professor, Indian Institute of Management Current trends and visions for the future for least developed developing countries in e.g. Africa Ogunlade Davidson, University of Sierra Leone, Co-chair of the IPCC Working Group III How do we make Denmark peak before 2020 when it comes to CO2? Jeppe Bjerg, Senior Analyst, IEA, Paris
16:00 – 16:30	Coffee break
16:30 – 18:00	5 parallel working groups **1. Future technologies and systems** Room 168, building 210 Chairman: Lars Hansen, Danish Energy Industries Federation Referee: Brian Elmegaard, Head of Section, Associate Professor, DTU Mechanical Engineering

2. Current trends and visions for the future for OECD Countries
Room 162, building 210
Chairman: Nicolai Zarganis, Head of Division, Danish Energy Authority
Referee: Stine Grenaa Jensen, Senior Advisor, Danish Energy Association

3. Current trends and visions for the future for big developing countries like India and China
Room 118, building 210
Chairman: John M. Christensen, Head of Centre, UNEP Risø Centre on Energy, Climate and Sustainable Development
Referee: Subash Dhar, Economist, UNEP Risø Centre

4. Current trends and visions for the future for least developed developing countries in e.g. Africa
Room 112, building 210
Chairman: Geert Aagaard Andersen, Head of Department, Ministry of Foreign Affairs of Denmark
Referee: Gordon Mackenzie, Senior Energy Planner , UNEP Risø Centre

5. How do we make Denmark peak before 2020 when it comes to CO_2?
Room 018, building 210
Chairman: Lars Hansen, Head of Department, Danish Energy Association
Referee: Peter Meibom, Senior Scientist, Risø DTU

19:00 – 21:00 Dinner in Faculty Club, DTU
Dinner speech by Knut Conradsen, Vice-Rector, Professor, DTU

20 November 2008 – Auditorium 54

09:00 – 09:30 Welcome
Niels Axel Nielsen, Director, Public Sector Consultancy, Technical University of Denmark
Morning speech by Lars Skovgaard, Senior Equity Advisor, Danske Bank

09:30 – 12:00 Yesterday's working groups continue

12:00 – 13:30 Lunch
Exposition arranged by Energy Crossroads

13:45 – 15:45 Presentation of main conclusions and panel discussion
Chairman: Hans Larsen, Head of Division, Risø National Laboratory for Sustainable Energy
In the panel:
Lars Hansen, Danish Energy Industries Federation
Nicolai Zarganis, Head of Division, Danish Energy Authority
John M. Christensen, Head of Centre, UNEP Risø Centre on Energy, Climate and Sustainable Development
Geert Aagaard Andersen, Head of Department, Ministry of Foreign Affairs of Denmark
Lars Hansen, Head of Department , Danish Energy Association
Jens Rostrup-Nielsen, Director, Special Projects, Haldor Topsoe A/S
Katherine Richardson, Chairman, the Danish Climate Commission

15:45 Refreshments

List of participants

Said Abdallah, Risø DTU

Bertel Lohmann Andersen, Techconsult

Glenn Klith Andersen, Calion Consulting

Stig Møller Andersen, BWSC A/S

Morten Andersen, Tech2people

Frits Møller Andersen, Risø DTU

Geert Aagaard Andersen, Ministry of Foreign Affairs of Denmark

Rasmus Saldern Antonsen, RUC

Rakesh K Arora, Embassy of India

Sabrina Azaiez, French Embassy in Denmark

Olexandr Balyk, Risø DTU

Martha Barcena Coqui, Embassy of Mexico

Henrik Bindslev, Risø DTU

Jeppe Bjerg, IEA, France

Jørgen Boldt, Wazee Consulting ApS

Svend Brandstrup Hansen, Danish Biofuel Holding as

Vibe Bregendahl Hansen, DR Nyheder

Rune Bro Roin, DONG Energy Oil & Gas

Uffe Bundgaard-Jørgensen, InvestorNet-Gate2Growth

Niels E. Busch, Busch & Partners

Thomas Capral Henriksen, Grontmij | Carl Bro

Henrik Carlsen, DTU Mechanical Engineering

Vladimir Cheburaev, Trade Representation of Russia in Denmark

Christian B. S. Christensen, Solum A/S

John M. Christensen, UNEP Risø Centre

Jørgen M. Clausen, Danish Energy Industries Federation

Knut Conradsen, DTU

Nicolaos Cutululis, Risø DTU

Kim Dam-Johansen, DTU Chemical Engineering

Jan Daub, Private

Ogunlade Davidson, University of Sierra Leone, Sierra Leone

Subash Dhar, UNEP Risø Centre

Sten Dieden, UNEP Risø Centre

Simon Dreyer, DI Energibranchen

Søren Dyck-Madsen, Danish Ecological Council

Thomas Egebo, Ministry of Climate and Energy

Claus Ekman, Risø DTU

Frank Elefsen, Danish Technological Institute

Anders Elmdrup, DONG Energy A/S

Brian Elmegaard, DTU Mechanical Engineering

Torben Engsig, Siemens A/S

Dmitry Filatov, Trade Representation of the Russian Federation

Jacob Fink Ferdinand, WWF Denmark

Jacob Fjalland, DIIS

Erik Friis-Madsen, Wave Dragon ApS

Chrysoula Galanaki, Greek Embassy

Klaus Gervin, KME

Valery Groshikov, Trade Representation of Russia in Denmark

Jørgen Gullev, Freelance journalist

Nikolay Gutor, Embassy of the Russian Federation

Pernille Hagedorn-Rasmussen, IDA

Kirsten Halsnæs, DTU Climate Centre, Risø DTU

Anders Bavnhøj Hansen, Energinet.dk

Jørgen K. L. Hansen, Firma Danrom Trading

Lars Hansen, Danish Energy Association

Flemming Hansen, DTU Space

Tom Hefting, SCP Consulting A/S

Carl Hellmers, Fredericia Fjernvarme

Jørgen Henningsen, European Policy Centre

Peter Hesseldahl, Impact by Danfoss

Kai Heussen, DTU-CET

Jacob Hjelm, DONG Energy Oil & Gas

Helge Holm-Larsen, Topsoe Fuel Cell A/S

He Huang, Mespom, UK

Jytte Illerup, DTU Chemical Engineering

Walter J. Sanchez, Roskilde University

Steen Hartvig Jacobsen, Kommunikationsbureauet Rubrik

Preben Jakobsen, Grundfos Management A/S

Klaus Rosenfeldt Jakobsen, Danish Agency for Sciences, Technology and Innovation

Edward James-Smith, Ea Energianalyse

Søren H. Jensen, MAN Diesel

Jakob Steen Jensen, SEED Capital

Stine Grenaa Jensen, Danish Energy Association

Lotte Jensen-Holm, Topsoe Fuel Cell

Jessica Jewell, IIIEE, Sweden

Birte Holst Jørgensen, Nordic Energy Research, Norway

Ioannis Karkanis, Greek Embassy

Illum Klaus, ECO Consult

Erik Koldby, ABB A/S

Jens Klæstrup Kristensen, Force Technology

Ole Krog, DI

Hans Larsen, Risø DTU

Nethe Veje Laursen, Risø DTU

Susanne Leth

Jesper Lund-Larsen, United Federation of Danish Workers

Gordon A. Mackenzie, UNEP Risø Centre

Frank Marcher, Danish Commission on Climate Change Policy

Alejandra Martinez Silva, Embassy of Mexico

Thomas Mathiasen, TM-Innovation

Peter Meibom, Risø DTU

Sara Moro, Risø DTU

Vivi Nymark Morsing, Risø DTU

Poul Erik Højlund Nielsen, Haldor Topsøe A/S

Susanne Balslev Nielsen, DTUmanagement

Gert Nielsen, Forvirk

Niels Axel Nielsen, DTU - Myndighedsbetjening og Sektorudvikling

Niels-Peter Nimb, Roskilde Universitetscenter

Nadeem Niwaz, Rambøll Danmark A/S

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Jyoti Prasad Painuly, UNEP Risø Centre

Knud Pedersen, DONG Energy A/S

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Lykke Ricard, DTU

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Risø DTU is the National Laboratory for Sustainable Energy. Our research focuses on development of energy technologies and systems with minimal effect on climate, and it contributes to innovation, education and policy. Risø has large experimental facilities and interdisciplinary research environments, and includes the national centre for nuclear technologies.

This report is part of a series of workshops and conferences arranged as a part of DTU Cimate Change Technology, a research programme run by the Technical University of Denmark.

DTU Climate Change Technologies aims to take scientific research, present it to key players in the fields of energy and climate changes to produce new technologies and processes. The goal is to reduce CO_2 emissions and support industrial production and welfare in adapting to climate change. Read more at dtu.dk/subsites/klima/English.aspx

Workshops

Sustainable Buildings - 19 June 2008
Future Energy Systems - 19 - 20 November 2008
Sustainable Energies - 14 - 15 January 2009
Animal Health and Food Safety - March 2009
Transport - renewable energy in the transport sector and planning - 17 - 18 March 2009
Climate Changes and Ecosystem Productivity - May 2009
Combustion, Carbon Capture and Storage - 27 - 28 May 2009
InfraStructure and Climate Changes - 1 September 2009

Research conferences

Changes of the Greenland Cryosphere - 25 - 28 August 2009
Risø International Energy Conference - 14 - 16 September 2009

Final round-up forum

High-level Conference - 17 September 2009

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